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QUAD_NAME	Sulphur 7½'
P_M_C_NAME (mine, claim & company names)	Rosebud Mine; Rosebud Mining Co. LLC
COMMODITY If not obvious	gold; silver
NOTES	Petrographic report; geology; photomicrographs mineral list 12 p.

Keep docs at about 250 pages if no oversized maps attached
(for every 1 oversized page (>11x17) with text reduce
the amount of pages by ~25)

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**PETROGRAPHY OF A VEIN SAMPLE FROM THE ROSEBUD MINE
AREA, NEVADA (SAMPLE RS-475-99, 2887.8')**

By

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**APPLIED PETROGRAPHICS
Tucson, Arizona**

27 September 1999

A Confidential Report Prepared For:

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INTRODUCTION

Sample RS-475-99, 2887.8' is a quartz vein intersected in an exploration drill hole from the vicinity of the Rosebud mine. Core logging and hand specimen examination identified tentatively the presence of pyrite accompanied by arsenopyrite, sphalerite, and galena in the vein sample. Applied Petrographics was requested to undertake a petrographic examination of the sample in order to characterize the vein type and mineralogy, and the possible relationship to the Rosebud epithermal vein system.

METHODOLOGY

A polished thin section of sample RS-475-99, 2887.8' was prepared by Quality Thin Sections of Tucson, Arizona. The section was examined subsequently in transmitted and reflected light using an Olympus BX60 polarizing microscope, and under cathodoluminescence using a Relion Industries Reliotron cathodoluminescence instrument mounted on an Olympus SZ60 stereo microscope with polarizing capability. Results are documented on photomicrographs taken with Nikon N2000 and Olympus OM-2 photographic systems. The photomicrographs accompany this report as Figures 1 - 10.

TRANSMITTED LIGHT

Sample RS-475-99, 2887.8' is a quartz vein that has been sheared and somewhat granulated (Figures 1 and 2). The quartz exhibits considerable variation in grain size, with a range from <0.05mm to nearly 6mm in length/diameter. The dominant quartz texture is xenomorphic-granular and polycrystalline. Pods of coarser-grained quartz that exhibit internal shear and annealing are encompassed by finer-grained granular quartz. A polysynthetically twinned mineral identified tentatively as plagioclase occurs locally with the quartz, a mineralogical feature that is perhaps unusual. The occurrence of plagioclase may be due to fragments of wall rock entrained in the vein, although I do not currently have data on the wall rock lithology. This interpretation is supported by the local presence of granulated plagioclase crystals, commonly proximal to, or in association with the zones of coarse quartz. "Ghost" wall rock fragments can be inferred by small, plagioclase-quartz-bearing areas crudely outlined by fine-grained opaque phases (Figure 3). If the plagioclase is interpreted as indigenous to the vein, then it is probably albite. An alternate possibility is that the "plagioclase" with polysynthetic twinning may be cordierite, which, in its unaltered state, is difficult to distinguish from plagioclase. If this phase is cordierite, then the wall rocks were probably argillaceous sedimentary rocks.

All of the quartz exhibits some degree of strain shadowing, but this feature is more strongly developed in the coarser quartz. Several crystals have a peculiar feathery strain shadowing (Figure 1a). Some quartz crystal boundaries appear to be granulated and subsequently annealed by recrystallization. The quartz vein is characterized by narrow sinusoidal stringers of carbonate, chlorite, sericite, and opaque minerals (Figures 1 and 2). The stringers contain generally fine-grained cubic opaque phases that accompany one or more members of the assemblage sericite-calcite-chlorite. One of the stringers blossoms into a boudin of coarser opaque phases (sub- to anhedral; to 1.2mm diameter). Opaque phases can occur also as sparse disseminations outside the sinusoidal stringers.

The main quartz vein appears to be cut by a generally coarser-grained, late (?) quartz-pyrite-calcite vein. In this sample the later vein is bounded by the sinusoidal sulfide-carbonate-sericite-chlorite±apatite stringers.

There is a linear, vein-like zone of carbonate and apatite at the edge of the slide. It is unknown as to whether this zone is integral to the vein or derived from the wall rock.

REFLECTED LIGHT

Opaque mineral phases identified in sample RS-475-99, 2887.8' under reflected light are:

- pyrite
- marcasite
- magnetite
- chalcopyrite
- sphalerite
- native gold
- arsenopyrite

The opaque minerals are dominantly pyrite. Pyrite occurs as generally euhedral to subhedral crystals that range to more than 1mm diameter, although most are in the range of <0.1mm to 0.5mm range. Cubic and rectangular are the most common crystal forms. Some of the pyrites appear to be mixed pyrite-marcasite crystals. Marcasite is also present as a discrete phase that appears to pseudomorph cubic pyrite crystals. The pyrite and subordinate marcasite are the preeminent opaque mineral constituents in the stringers that transect the vein (Figures 4 and 5). One subhedral pyrite crystal noted along an undulatory stringer appears to have a core of magnetite (?; gray, isotropic, relatively low reflectance; Figure 5). Magnetite could well be a stable or metastable phase in this vein assemblage because the plagioclase presumably derived from the wall rocks is unaltered. The magnetite may be relict from the wall rock and possibly served as a nucleation site for the pyrite in this case.

Traces of very fine-grained (<0.025mm length), anhedral chalcopyrite accompany some pyritic stringers, and one stringer was found to host a trace of extremely fine-grained (<0.004mm length) native gold (Figure 4). Several irregular aggregates of motheaten sphalerite crystals are present in the vein and form intergranular to the quartz (Figure 6). The largest aggregate is approximately 1 mm in length, and the sphalerite shows characteristic yellow-brown internal reflections. Sphalerite occurs also as sparse disseminations in the vein. One irregular sphalerite crystal (appx 0.25mm diameter) contains tiny blebs of chalcopyrite (Figure 7).

Possible traces of very fine-grained (<0.015mm) arsenopyrite (?) were identified in one of the stringers and as sparse disseminations (Figure 8). The phase is characterized by creamy white color, moderate to high reflectance, and distinct anisotropy under incompletely crossed nicols. The identification is tentative, however, because the phase is anhedral and lacks the characteristic rhomb-shaped sections. There is an extremely fine-grained (<0.003mm diameter), anhedral phase that occurs locally with pyrite in the sinusoidal stringer zones. It is too fine-grained to obtain a positive identification, but may be pulverized magnetite.

CATHODOLUMINESCENCE (CL)

Cathodoluminescence features of sample RS-475-99, 2887.8' are illustrated in figures 9 and 10.

Quartz has a very dull red CL response. There does not appear to be a difference in CL response between the coarse and finer-grained quartz. It should be noted that most of the vein and breccia quartz examined under CL from other Rosebud samples does not luminescence.

The polysynthetically twinned mineral identified as plagioclase has a very dull brownish gray CL response, insufficient to distinguish it from cordierite. Most of the plagioclase is concentrated near a vein-like zone of carbonate and abundant apatite at the edge of the slide, although there are scattered crystals in the interior of the slide, also associated with a cloudy carbonate-apatite assemblage.

Two carbonate varieties appear to be present. An early carbonate identified tentatively as dolomite (or calcite with a higher Fe abundance) is disseminated in the vein and is also a component of the sinusoidal stringer zones with pyrite-sericite±chlorite. It is also the dominant component of a vein-like carbonate-apatite zone at the edge of the slide. This carbonate has a dull to moderate red to orange-red CL and has an abundance of perhaps 2-3%. The second, later, carbonate is calcite. Calcite has bright orange CL (Mn²⁺ activation). The calcite fills intercrystalline voids and forms small, discontinuous stringers that appear to cut the earlier, more iron-rich carbonate. Calcite is also a prominent component in the late quartz-calcite - pyrite that cuts the main vein. Calcite abundance is approximately 1-2%.

Apatite has strong grayish to greenish-yellow CL. It occurs as fine-grained, euhedral to subhedral crystals. Apatite is highly concentrated in the vein-like carbonate-apatite zone at the edge of the slide. Apatite occurs also disseminated in the vein and as a component of some of the sinusoidal carbonate-sericite sulfide stringers. Overall apatite abundance is approximately 0.25%

SUMMARY AND CONCLUSIONS

The character of the quartz vein from sample RS-475-99, 2887.8' is unlike other veins that I have examined from the Rosebud area, although my study of the large sample suite from the Rosebud mine area is as yet incomplete. The vein in question here is marked by several characteristics that render it unique among Rosebud veins that I have examined:

- The vein is sheared and exhibits considerable variation in quartz grain size.
- The vein contains sparse plagioclase (or cordierite) and magnetite, although these phases may be derived from wall rock (I currently have no information as to wall rock lithology). If the plagioclase is indigenous to the vein, it is probably albite.

- The vein contains sinusoidal stringers of sulfide (py-mc-cp) mineralization. The stringers could have formed under the influence of shear deformation.
- The vein contains significant apatite, generally in association with iron-rich carbonate. Apatite has been noted associated with some, but not all, quartz-carbonate-sulfide veins elsewhere in the Rosebud mine area.

The major similarity between the quartz vein in sample RS-475-99, 2887.8' and other veins from the Rosebud mine are that I have examined is that the dominant sulfide phases are the same. Composite pyrite-marcasite crystals are present in the vein described in this report, while skeletal pyrite-marcasite crystals are the most common sulfide mineralogy in veins from the Rosebud district, based on samples that I have examined to date.

It cannot be said with certainty that the vein sample RS-475-99, 2887.8' is of epithermal origin and related to the mineralized veins of the Rosebud gold-silver deposits. It is likely that the vein represents an earlier episode of vein mineralization. It seems likely, however, that the mineralization episode that produced the Rosebud deposits has overprinted this vein to some degree. The productive Rosebud mineralization event may be represented by the coarser-grained, late quartz-calcite-pyrite vein illustrated in Figure 2.



Figure 1a. Sample RS-475-99, 2887.8'. Sinusoidal sulfide-bearing stringer in the quartz vein. The stringer also contains calcite and apatite in addition to pyrite and minor chalcopyrite. There is a large variation in quartz crystal size. The large quartz crystals in the upper part of the photo have internal shears annealed by recrystallization. Note feathery strain-shadowing in a quartz crystal at lower left. Transmitted light, crossed polars (TLX); 1 cm on photo=0.532mm.

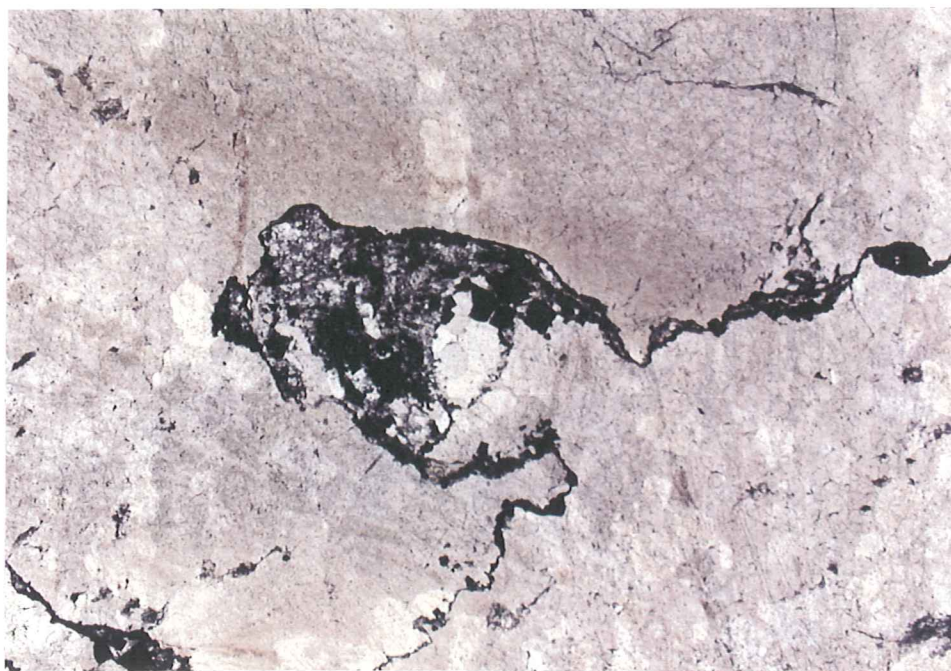


Figure 1b. Sample RS-475-99, 2887.8'. Same view. Transmitted light, uncrossed polars (TLP); 1 cm on photo=0.532mm.

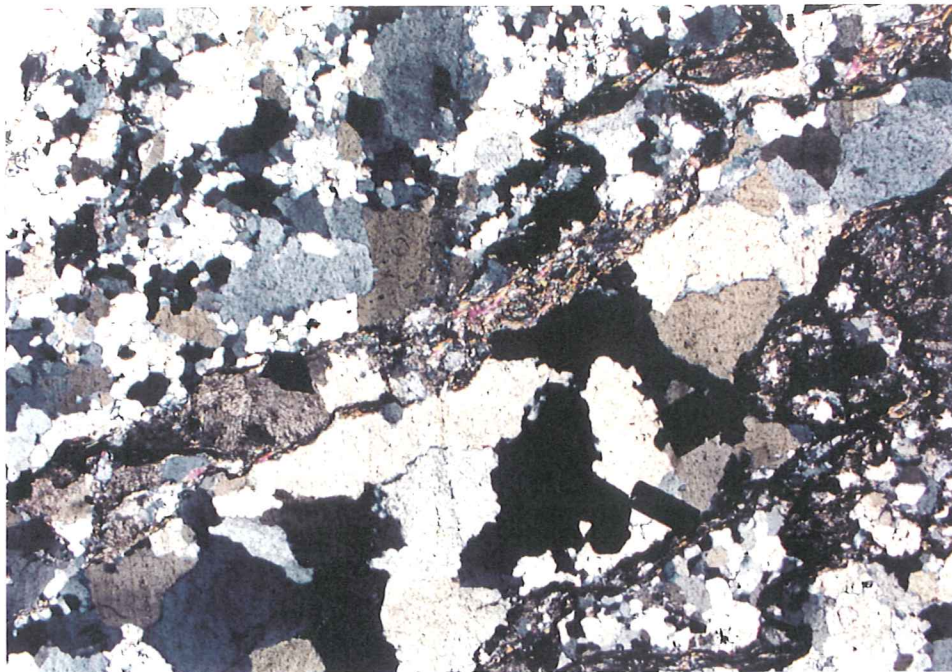


Figure 2a. Sample RS-475-99, 2887.8'. Quartz-pyrite-calcite vein cutting the main quartz vein (calcite not shown in this view). This later vein is bounded by stringers of calcite-sericite-pyrite (+minor apatite and chlorite).

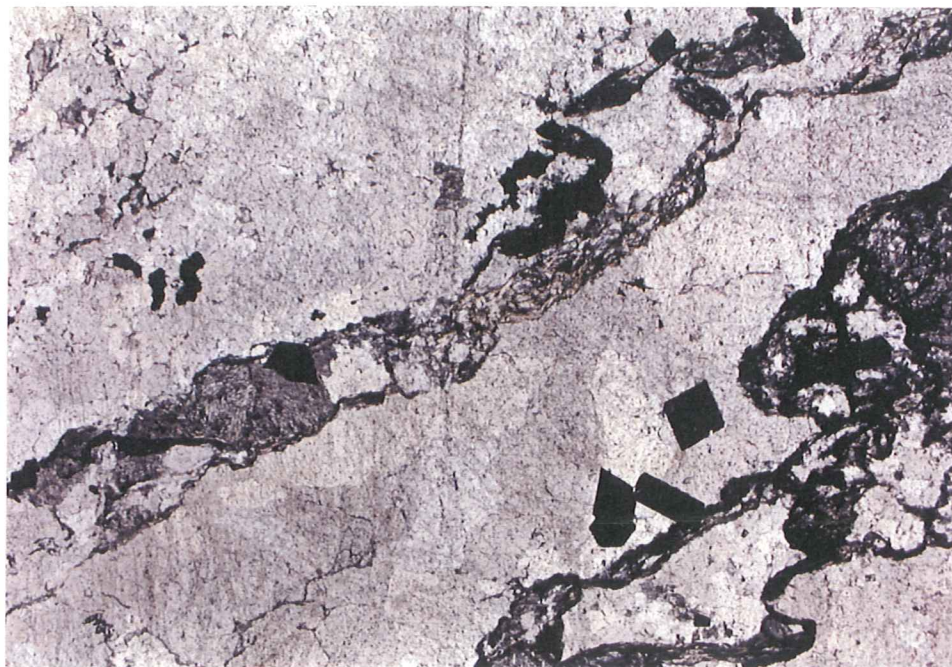


Figure 2b. Sample RS-475-99, 2887.8'. Same view. TLP; 1cm on photo=0.532mm.

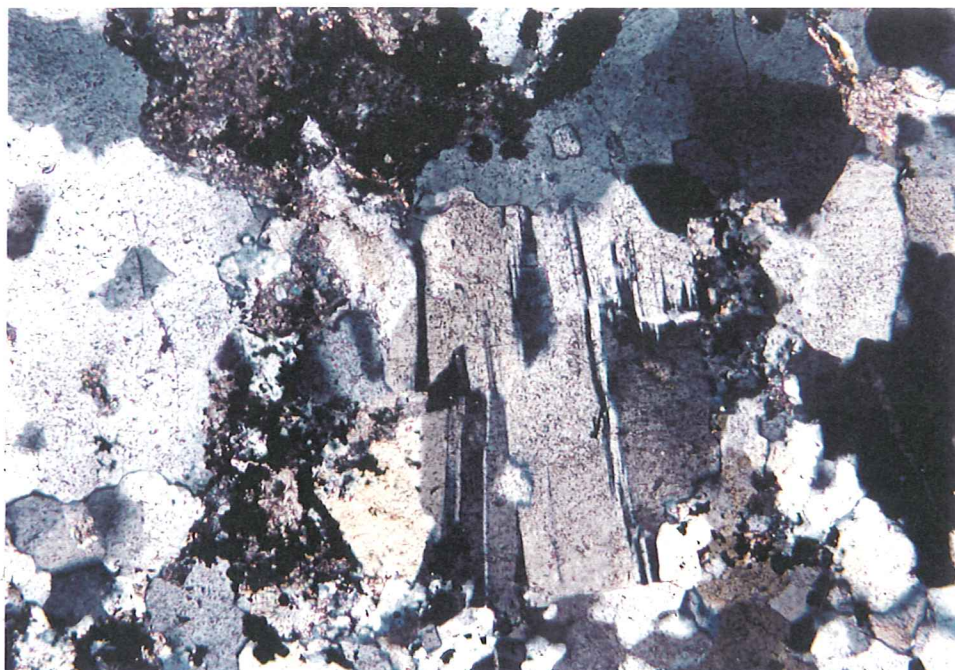


Figure 3a. Sample RS-475-99, 2887.8'. Plagioclase-bearing wall rock fragment ("ghost fragment") outlined crudely by a narrow zone of carbonate and pyrite. TLX; 1cm on photo=0.106mm.

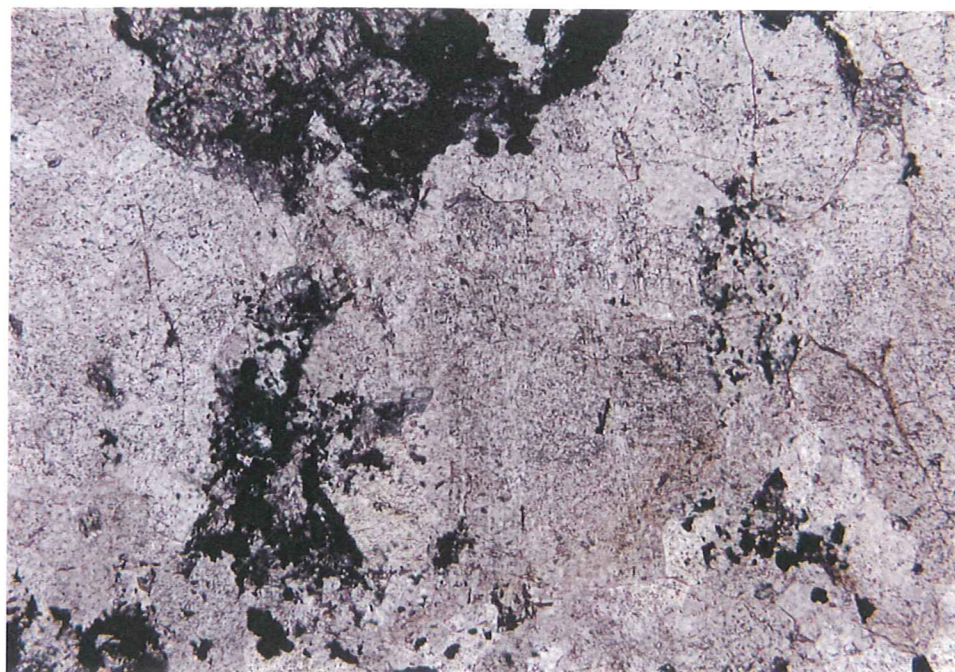


Figure 3b. Sample RS-475-99, 2887.8'. Same view as Figure 3a. Note how fine oipaques (pyrite) appear to outline the plagioclase(?) -bearing "ghost" wall rock fragment. TLP; 1cm on photo=0.106mm.

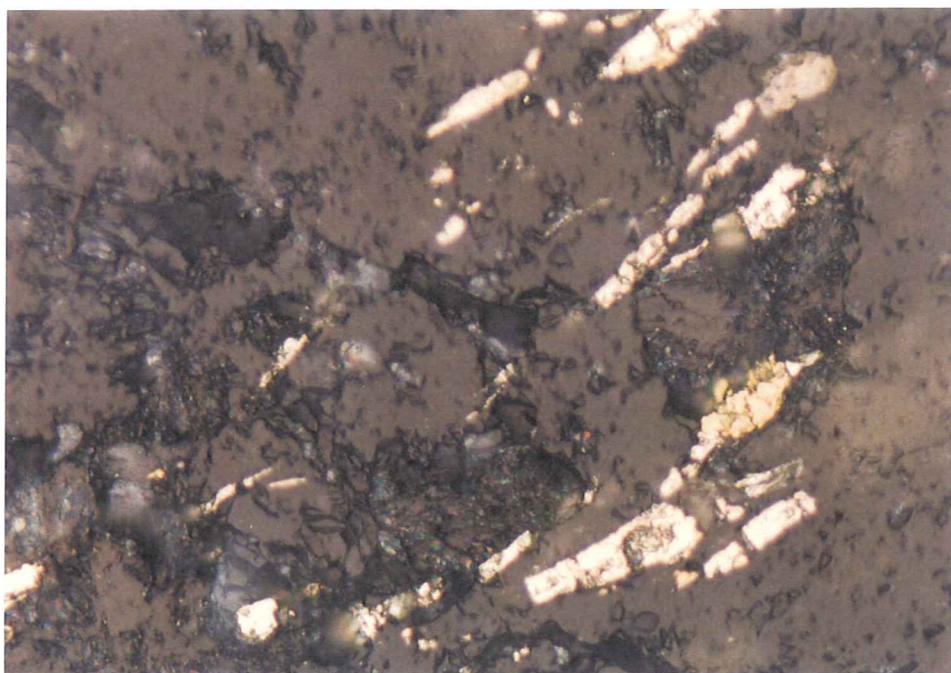


Figure 4. Sample RS-475-99, 2887.8'. Discontinuous pyrite stringers with minor chalcopyrite (near right edge center; yellow with moderately high reflectance). A tiny grain of native gold (yellow, high reflectance) is present in the lower left quadrant of the photo. Reflected light (RL); 1 cm on photo=0.021 mm.

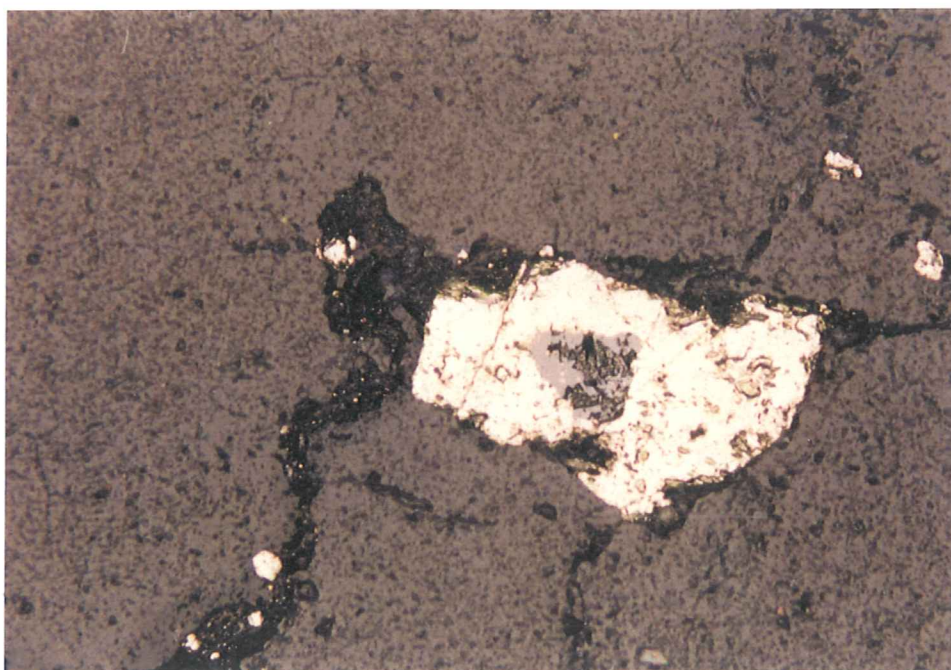


Figure 5. Sample RS-475-99, 2887.8'. The larger pyrite crystal in this sinusoidal stringer has a core of magnetite (gray color; low reflectance; isotropic; no internal reflections). RL; 1 cm on photo=0.053 mm.

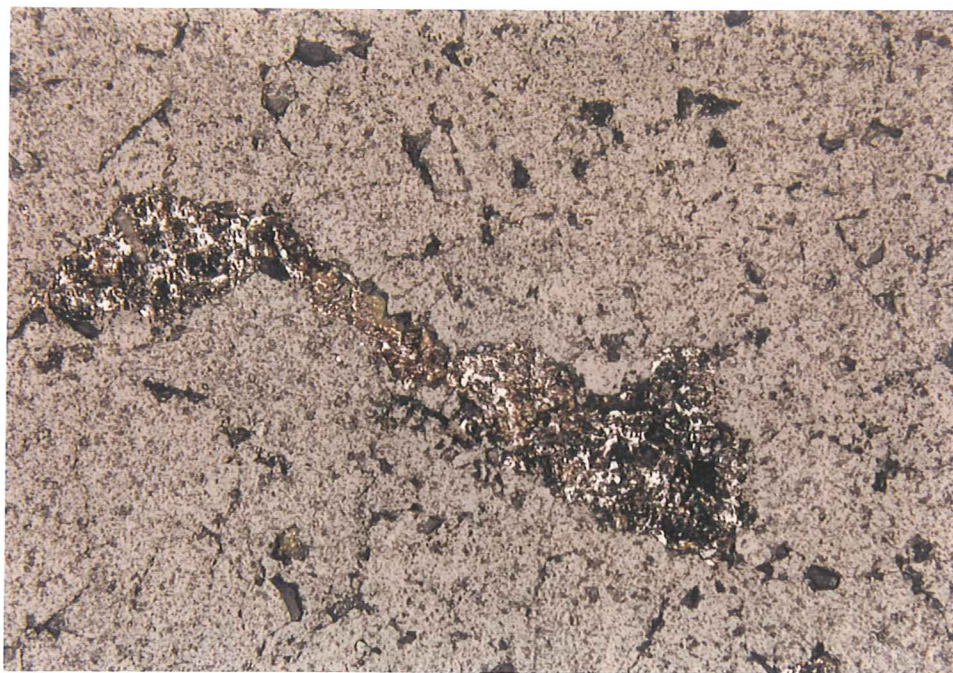


Figure 6. Sample RS-475-99, 2887.8'. Irregular aggregate of motheaten sphalerite crystals (gray; low reflectance; yellow brown internal reflections under crossed polars. RL; 1cm on photo=0.106mm.

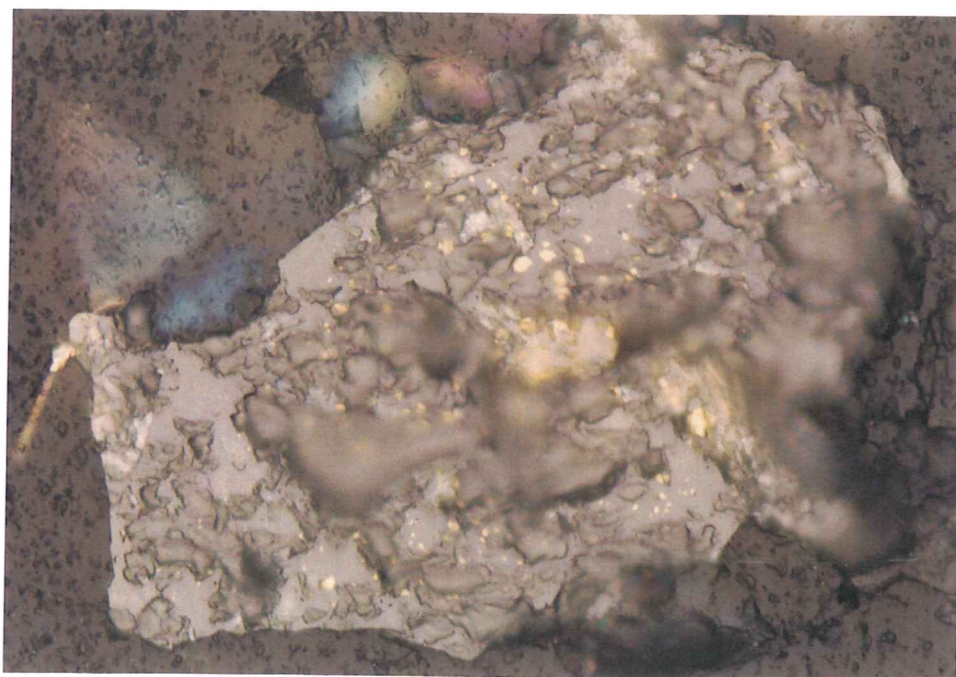


Figure 7. Sample RS-475-99, 2887.8'. Irregular sphalerite crystal with blebs of chalcopyrite. RL; 1cm on photo=0.021mm.

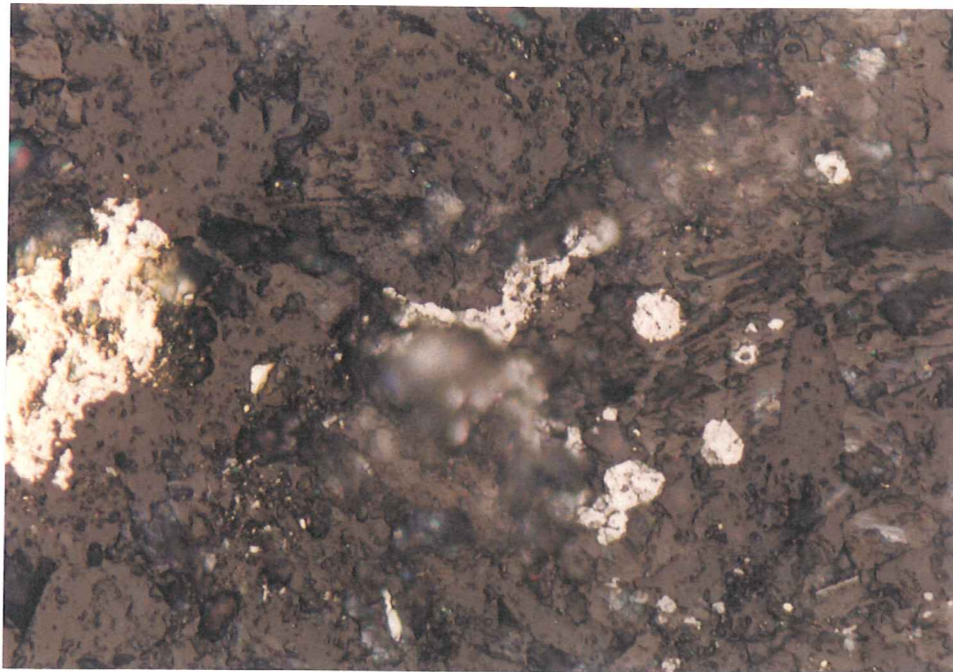


Figure 8. Sample RS-475-99, 2887.8'. Irregular pyrite crystal (whitish yellow color; moderately high reflectance) and a very fine-grained phase characterized by white color, moderately high reflectance, and distinct anisotropy under crossed polars. This phase may be arsenopyrite, although the grains lack the characteristic rhomb-shaped crystal form. RL; 1cm on photo=0.021mm.

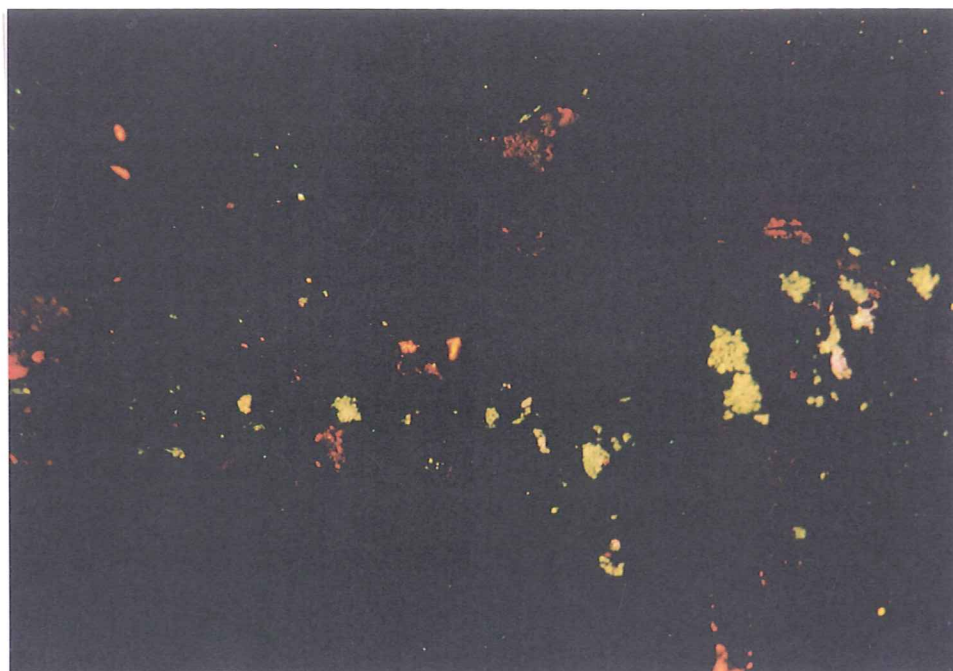


Figure 9a. Sample RS-475-99, 2887.8'. Cathodoluminescence (CL) photomicrograph showing iron-rich calcite or dolomite (reddish orange CL; Mn²⁺ activation) and apatite (bright greenish yellow CL; Mn²⁺ activation) accompanying pyrite and sericite in a sinusoidal stringer in the quartz vein. CL; 1cm on photo=0.336mm.

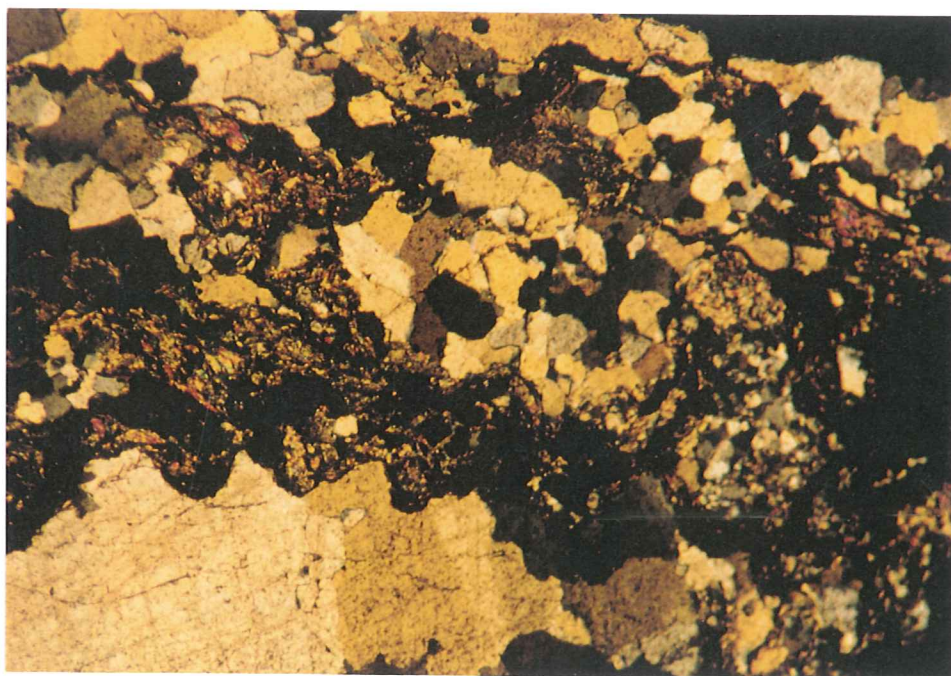


Figure 9b. Sample RS-475-99, 2887.8'. Same view as in Figure 9a, except under transmitted light. TLX; 1cm on photo=0.336mm.



Figure 10. Sample RS-475-99, 2887.8'. CL photomicrograph showing a vein-like zone of iron-rich calcite or dolomite (reddish orange CL) and relatively abundant apatite (yellow to greenish yellow CL) at the edge of the slide and in contact with the vein quartz (non-luminescent). Later calcite has bright orange CL (Mn^{2+} activation). The quartz has a dull reddish CL. CL; 1 cm on photo=0.336mm.